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A Swedish primary healthcare prevention programme focusing on promotion of physical activity and a healthy lifestyle reduced cardiovascular events and mortality: 22-year follow-up of 5761 study participants and a reference group

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ABSTRACT

Objective To evaluate long-term risk of first cardiovascular (CV) events, CV deaths and all-cause deaths in community-dwelling participants of a cardiovascular disease (CVD) prevention programme delivered in a primary care setting.

Methods Individuals who visited a primary healthcare service in Sollentuna (Sweden) and agreed to participate in the programme between 1988 and 1993 were followed. They had at least one CV risk factor but no prior myocardial infarction and received support to increase physical activity using the programme Physical Activity on Prescription and to adopt health-promoting behaviours including cooking classes, weight reduction, smoking cessation and stress management. Participants (n=5761) were compared with a randomly selected, propensity score-matched reference group from the general population in Stockholm County (n=34 556). All individuals were followed in Swedish registers until December 2011.

Results In the intervention group and the reference group there were 698 (12.1%) and 4647 (13.4%) first CV events, 308 (5.3%) and 2261 (6.5%) CV deaths, and 919 (16.5%) and 6405 (18.5%) all-cause deaths, respectively, during a mean follow-up of 22 years. The HR (95% CI) in the intervention group compared with the reference group was 0.88 (0.81 to 0.95) for first CV events, 0.79 (0.70 to 0.89) for CV deaths and 0.83 (0.78 to 0.89) for all-cause deaths.

Conclusions Participation in a CVD prevention programme in primary healthcare focusing on promotion of physical activity and healthy lifestyle was associated with lower risk of CV events (12%), CV deaths (21%) and all-cause deaths (17%) after two decades. Promoting physical activity and healthy living in the primary healthcare setting may prevent CVD.
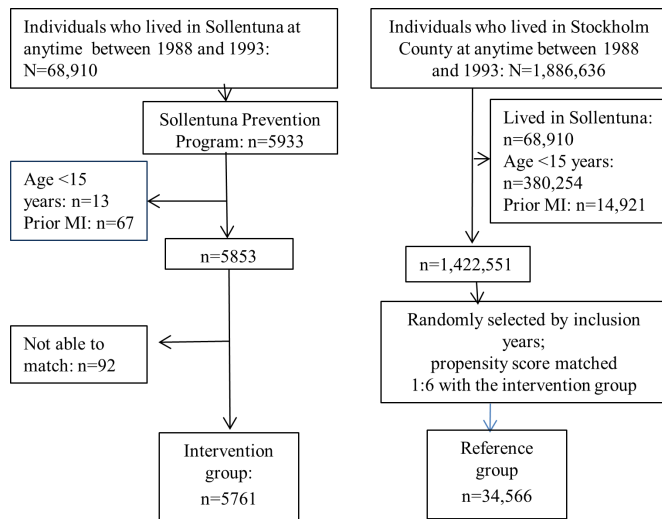
INTRODUCTION

Understanding on the importance of lifestyle interventions in cardiovascular disease (CVD) prevention has increased substantially over the past decades. Through a physically active and healthy lifestyle most of the CVDs can be prevented.[1] Today several randomised controlled studies have demonstrated that a healthier lifestyle and improvements in lifestyle-related risk factors can reduce cardiovascular (CV) morbidity and mortality.[2 3] Accordingly, guidelines for the prevention of CVD have emphasised lifestyle interventions as the basis for both primary and secondary prevention for at least 30 years.[4–7]

Many attempts have been made to implement guidelines in clinical practice. Several CVD prevention programmes have shown improvements in risk factors for CVD.[8] However, studies of CVD prevention programmes in primary healthcare have shown contradictory results with regard to their ability to reduce CVD events.[8–10] There is therefore a need for well-controlled studies of the potential effects of lifestyle interventions and CVD prevention programmes to gain a better understanding of how effective prevention programmes can be implemented in clinical practice.

The aim of this study was to evaluate long-term risk of first CV events, CV deaths and all-cause deaths in individuals taking part in a primary healthcare-based CV prevention programme focusing on physical activity and healthy lifestyle, compared with a matched reference group from the general population.

METHODS

The Sollentuna Prevention Program (SoPP), which combined an individual and population-based approach, was initiated in August 1988 at all four primary healthcare centres in Sollentuna Municipality. The CVD prevention programme has been described in detail elsewhere.[11 12] In brief, visitors to healthcare centres were invited to participate in the programme. A self-administered questionnaire was used for the initial screening, followed by a physical examination by a general practitioner or nurse.[11] Weight, height and resting blood pressure were measured, and fasting blood samples were collected. Established guidelines for CVD prevention were used for advice on lifestyle, as well as treatment, and follow-up of identified CVD risk factors.[13–15]

Promotion of a healthy lifestyle

The programme focused on lifestyle intervention, and all participants received individualised and customised advice, and a large selection of different

Figure 1 Study flow chart. MI, myocardial infarction.

educational groups and a lecture series were available as support (online supplementary S1).

The programme promoted a physically active lifestyle. A new tool to promote physical activity—Physical Activity on Prescription—was developed. Registered healthcare professionals were educated to issue a referral for supervised training at a local sports association. The number of exercise groups grew rapidly, and after 10 years (1997) 27 different groups were available with 15–20 individuals in each group. The method has been described in more detail elsewhere.[12]

Group sessions were occasionally available also for cooking, weight reduction, smoking cessation and stress management. Weekly public lectures for participants and their relatives

focusing on healthy lifestyle and behavioural changes were offered for 17 years.

Health centre staff received continual training in lifestyle medicine and behavioural science according to guidelines. An overview of the lifestyle intervention can be found in online supplementary S1. In parallel with the screening and prevention programme offered to visitors at the healthcare centres (individual strategy), a population-based programme was also running. During the first 10 years, some 50 meetings were held in grocery stores, libraries, schools, leisure centres, for associations, dental care and more. The purpose was to inform employees at these units about the programme and to disseminate knowledge about the importance of lifestyle in preventing CVD.

Study population

The prevention programme was launched in 1988 in Sollentuna Municipality (n=50 242) in Stockholm County. The intervention group comprised residents of Sollentuna who visited a primary healthcare centre and agreed to participate in the SoPP between 8 August 1988 and 12 December 1993. The intervention group of the present study included 5761 individuals, 15 years of age or older, with one or more CVD risk factors and no prior myocardial infarction (figure 1). The reference group was identified using yearly registers (maintained by Statistics Sweden) of the total population in Stockholm, Sweden on 31 December each year during the inclusion period. Using these registers, a cohort corresponding to the total dynamic population of Stockholm County (n=1 886 636) was established. After exclusion of subjects residing in Sollentuna during the inclusion period, 1 422 551 participants aged 15 years or older with no prior myocardial infarction were included in the study (figure 1).

Propensity score (PS) matching was used and accounts for differences in baseline characteristics between the intervention and reference groups, considering demographic, socioeconomic

Table 1 Baseline characteristics of the intervention group for all and for men and women compared with the reference group after propensity score matching

Variable	Intervention group n=5761	Reference group n=34 566	Intervention group (men) n=2087	Reference group (men) n=12 472	Intervention group (women) n=3674	Reference group (women) n=21 824
Female, %	63.8	63.1				
Age, years (SD)	45.6 (13.7)	45.6 (13.9)	46.2 (14.0)	46.2 (14.2)	45.2 (13.5)	45.2 (13.7)
Married, %*	64.9	65.2	68.6	67.9	62.7	63.7
Born in Sweden, %	84.7	84.4	84.0	83.2	85.1	85.1
Sick leave before inclusion, %	76.6	77.0	72.7	73.7	78.9	78.9
Sick leave within the last year before inclusion, %	59.0	58.6	52.3	52.1	62.8	62.3
Charlson index (SD)	0.2 (0.6)	0.2 (0.6)	0.2 (0.6)	0.3 (0.7)	0.2 (0.6)	0.2 (0.6)
Education <10 years (low), %†	26.2	26.0	26.3	25.9	25.8	26.4
Education 10–12 years (medium), %	43.7	44.1	44.7	44.0	43.6	43.6
Education >12 years (high), %	30.1	30.0	29.0	30.1	30.6	30.0
Year of inclusion, %						
1988	16.0	16.0				
1989	30.0	30.0				
1990	26.4	26.4				
1991	14.0	14.0				
1992	11.1	11.1				
1993	2.5	2.5				

*Missing data for marital status were included in the non-married group (intervention group 0.9%, reference group 0.03%).
†Missing data for education level were included in the low education group (intervention group 2.0%, reference group 2.0%).

and health-related variables, as described in table 1 and online supplementary table S2. This method was used to mimic a randomised control study in achieving a balanced intervention and reference group and reduce selection bias in observational data. For each subject in the intervention group six subjects were randomly selected from the general population cohort (n=34 566). For PS matching, a maximum calliper width of 0.20 was used and we were able to include all subjects except for 92 who were not able to match to the intervention group.

Sources for baseline characteristics and outcome data

All subjects in the intervention and reference groups were linked to national registers from the National Board of Health and Welfare, Statistics Sweden, and The National Insurance Agency using the Swedish 10-digit unique personal identification number.

In the intervention group, age, sex and CVD risk factors were recorded at the time of inclusion (online supplementary table S2). Information about sociodemographic characteristics (age, sex, marital status, place of birth, level of education (low, medium, high) and migration) was obtained from the National Population Register at Statistics Sweden. Records of sick leave at any time before inclusion as well as within the last year before inclusion were obtained from the Microdata for the Analysis of Social Insurance register at The National Insurance Agency. History of comorbidity was obtained from the National Patient Register, and data on death were retrieved from the Swedish Cause of Death Register. Deaths were classified by cause and registered according to International Classification of Diseases, 9th revision (ICD-9) and 10th revision (ICD-10) codes. The Charlson comorbidity index (CCI) was estimated using ICD codes for comorbidities.[16 17] CCI is a commonly used index originally developed to classify prognostic comorbidity in longitudinal studies.[16] Both main and secondary diagnoses were included in the calculation of the index. Prescribed drug treatments such as lipid-lowering drugs, antihypertensives, antidiabetics and insulin treatment were not available for the whole study period, but were retrieved from the Swedish Drug Registry in 2005 (July–December) and 2011.

Follow-up started when individuals entered the prevention programme (intervention group) or were selected from the general population cohort (reference group) between 1988 and 1993. The National Patient Register and the Swedish Cause of Death Register identified new cases of first CV events (acute myocardial infarction, stroke or CV death) and deaths due to CVD and all causes during the follow-up, respectively. Follow-up of the intervention and reference groups ended at first CVD event, death, emigration or 31 December 2011, whichever came first.

Definition of outcome measures

A CV event was defined as hospitalisation or death with a main diagnosis of acute myocardial infarction (ICD-9 410; ICD-10 I21, I23), stroke (ICD-9 431, 432, 434, 436; ICD-10 I61, I63, I64) or other CVD (ICD-9 390–459; ICD-10, I00–I99). CV death (ICD-9, 390–459; ICD-10 I00–I99) and all-cause death were identified by linkage to the Cause of Death Register in Sweden.

Statistical analysis

Categorical data were presented as percentage and continuous variables as mean and SD or median and IQR. To balance the intervention and the reference group by PS matching, data

from national registers, as described in table 1, were used. HRs comparing event rates over time for all outcomes between the intervention and the reference group were calculated using Cox proportional hazard regression. Multivariable analysis verified that the predictors of mortality and CVD events were similar in the two samples (Sollentuna vs the rest of Stockholm). Non-parametric Nelson-Aalen estimator was used to estimate the cumulative hazard function from censored survival data. Analysis of residuals according to Schoenfeld verified the proportionality of the proportional hazards assumption.[18]

The SAS V.9.4 statistical package was used for analysis.

Patient and public involvement

When the prevention programme was planned and designed in 1986–1988, there was no involvement of patients or the public. Politicians and officials from Stockholm County Council participated in the planning of the follow-up study.

RESULTS

Characteristics of the study population

Baseline characteristics differed between the intervention and the reference group before PS matching, with a greater proportion of women, a higher mean age and a higher percentage of sick leave before inclusion in the intervention group (online supplementary table S3). After PS matching, baseline characteristics were well balanced between the intervention (n=5761) and the reference (n=34 566) group (table 1).

In both groups the mean age was 45.6 years, 63% were women, 65% were married, 84% were born in Sweden, 77% took sick leave before inclusion and 59% within the last year of inclusion, Charlson index was 0.2, and most participants achieved a medium level of education (44%) (table 1 and online supplementary table S3). Data extracted from the Swedish Drug Registry in July–December 2005 and in 2011 showed that both men and women in the intervention group were more often prescribed lipid-lowering drugs, antihypertensives and antidiabetic drugs than men and women in the reference group (online supplementary tables S4 and S5).

Main outcomes

The median follow-up was 22 years (IQR 19–23 years). In the intervention group (n=5761) there were 698 first CV events, 308 CV deaths and 919 all-cause deaths during follow-up. In the reference group (n=34 566) there were 4647 CV events, 2261 CV deaths and 6405 all-cause deaths. The incidence of first CV events, CV deaths and all-cause deaths reduced by 12%, 21% and 17%, respectively, in the intervention compared with the reference group. The HR in the intervention group compared with the reference group was for first CV event 0.88 (95% CI 0.81 to 0.95; p<0.001), for CV deaths 0.79 (95% CI 0.70 to 0.89; p<0.001) and for all-cause deaths 0.83 (95% CI 0.78 to 0.89; p<0.001). The Nelson-Aalen curves separated for all main outcomes in the first few years of follow-up, and the separation continued for two decades (figure 2A–C). Reductions in CV events and mortality in the intervention group compared with the reference group were found in both sexes (online supplementary figure S1).
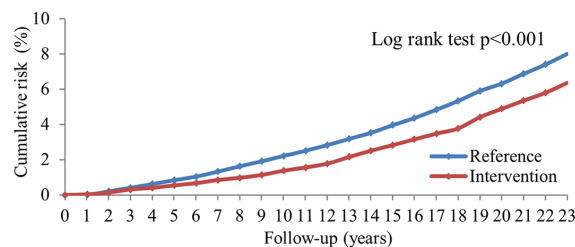
We estimated that 175 premature deaths were prevented or delayed in the intervention group of 5761 individuals during a follow-up of approximately two decades (15/10 000/year) (online supplementary table S6).
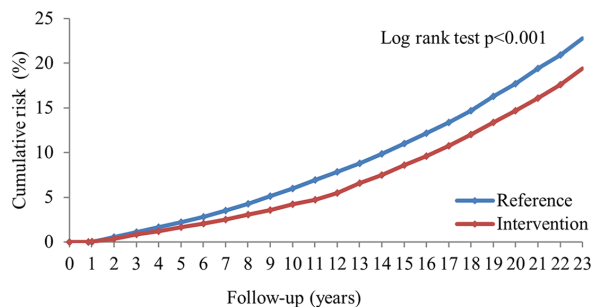
A. First cardiovascular event.
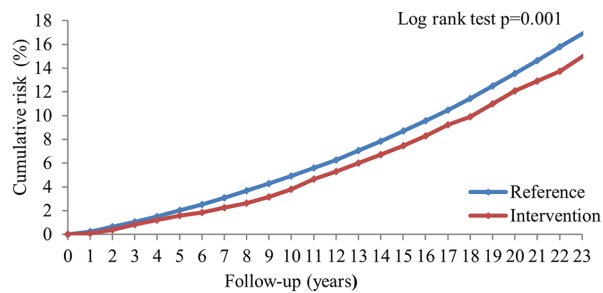
Number at risk
Reference	34,566	32,920	30,761	28,469	22,456
Intervention	5761	5537	5269	4903	3885

B. Cardiovascular death.

Number at risk
Reference	34,566	33,294	31,526	29,673	23,859
Intervention	5761	5592	5391	5114	4141

C. All-cause death.

Number at risk
Reference	34,566	33,295	31,527	29,677	23,858
Intervention	5761	5597	5391	5116	4144

Figure 2 Risk of first cardiovascular event (A), cardiovascular death (B) and all-cause death (C) during the follow-up period.

DISCUSSION

In this long-term follow-up of a CVD prevention programme that emphasised promotion of physical activity and other lifestyle interventions, we found a 12%–21% lower risk of first CV event, CV death and all-cause death in the intervention group compared with a well-balanced, PS-matched reference group from the general population in Stockholm County. Lifestyle interventions included prescription of physical activity and information and support on how to follow a healthy diet, lose weight, manage stress and cease smoking. In the programme, individual and population strategies were combined to enhance the preventive effects. In addition, well-educated staff ran the programme which was fully integrated in clinical practice.

Previous evaluations of CV prevention programmes

Few previous studies of CVD primary prevention programmes have been published that provide individual long-term

follow-up data on morbidity and mortality. A systematic review of randomised controlled studies of CVD risk factor interventions in general populations showed small reductions in CVD risk factors and no effects on CV events.[19] However, the median follow-up period was only 12 months, which may be too short to detect effects on CVD and death. A 6-year follow-up of community CVD prevention programmes in the USA during the 1980s (Stanford Five-City Project, Minnesota Heart Health Program and Pawtucket Heart Health Program) failed to show any reduction in coronary heart disease mortality.[20] A systematic review of multifactorial community interventions showed improvements in CVD risk factors but small effects on death.[21] By contrast, a long-term follow-up of the Finnish North Karelia community project showed a reduction in CV deaths.[22] Recently, long-term follow-up studies of individual and population-based CVD prevention programmes in the USA (the Franklin Cardiovascular Health Program) and in northern Sweden (the Västerbotten Intervention Programme) showed reductions in CV and all-cause deaths compared with the general population.[23 24] However, most of the previous prevention programmes were evaluated using data before and after the intervention and did not include a well-matched reference group.[8]

Effects on CV risk factors and CV risk within the prevention programme in Sollentuna and other prevention programmes

A previous follow-up study of participants from the prevention programme in Sollentuna showed significant reductions in several CV risk factors among subjects with increased CV risk factors at baseline.[25] These results indicated that the programme was successfully implemented and that the participants adhered to the advice given.

The new working method for prescribing physical activity in collaboration with local sport club was later on evaluated and became an early model for promotion of physical activity nationally and also internationally.[26–28] Recently, a systematic review showed that the Swedish model led to increased physical activity and the conclusion was that it can be used routinely in healthcare.[29]

The methods used in the prevention programme to increase participants' physical activity and to support healthier eating habits were also evaluated in a randomised controlled trial among middle-aged men with elevated CV risk. The methods reduced a majority of CV risk factors after 6 months and 18 months.[30] The methods were also cost-effective.[31]

In a study of the whole population in Sollentuna between 1990 and 2010, we found a lower incidence of acute myocardial infarction in Sollentuna Municipality compared with the rest of Stockholm County, especially among women.[32] A combined individual and population CVD intervention project in the northern Sweden showed that women had a lower incidence of CVD and all-cause mortality compared with the general Swedish population.[24] In the present study, both men and women in the intervention group compared with the reference group had lower rates of CV events, CV death and all-cause death.

Data from 2005 and 2011 showed that both men and women who participated in the prevention programme were more often prescribed CV drugs than their counterparts in the reference group. Since those who participated in the prevention programme had at least one known CV risk factor, it is more likely that they would receive drug treatment.

However, the results of the prevention programme exceeded the strong secular trends towards reduced CVD incidence and mortality during the same period in Stockholm County.

Is the effect size clinically meaningful?

The incidence of first CV events, CV deaths and all-cause deaths reduced in individuals who participated in the prevention programme compared with the reference population. Among the 5761 participants 175 premature deaths were estimated to be prevented or delayed, which corresponded to 15 saved lives per 10 000 per year. The Swedish primary healthcare is well developed, and during a decade almost the entire population in a certain area have visited their health centre for some reason. If the programme should be implemented in all regions in Sweden, the effects on health would be substantial. However, a health economic evaluation remains to be done and is being planned.

Study strengths

An important strength of our study is the long-term follow-up, as such investigations of extensive CV prevention programmes are very few. Furthermore, the study included both men and women. Another important strength was our study design, which was made possible by the unique infrastructure of registers in Sweden. We used Swedish historical population registers to reconstruct the population of Stockholm County during the period of the prevention programme for identification of a relevant reference group. To reduce the potential impact of confounding by indication, we used a PS-matched comparison of the intervention group with randomly selected referent subjects. The matched groups were balanced with regard to all measured baseline characteristics. Both the intervention and reference cohorts were linked to high-quality national registers of hospitalisations and deaths with a high degree of completeness for follow-up of CV events and deaths.[33][34] There were essentially no loss of deaths or diagnosed CV events during the follow-up period of more than 20 years. To reduce misclassification of first CV events we used information on hospitalisations regionally going back to 1964 and nationally from 1987.

Study limitations

Our study has limitations. The design was observational and the enrolment of the intervention group was voluntary. Individuals with healthy behaviour may be more interested in participating in prevention programmes.[35] On the other hand, effects of the prevention programme on lifestyle habits may have extended to other municipalities in Stockholm County and the effects from our prevention programme might therefore have been diluted. Participation in the prevention programme seemed to increase the prescription of CV drugs (year 2005 and year 2011), which also may have contributed to the outcomes.

Another source of bias in this study may be that it was not possible in PS matching to account for baseline data for CVD risk factors, lifestyle factors, drug treatment (before July 2005) and non-hospitalised comorbidity.[36] Such data are not available in current Swedish national registers. Although the intervention and reference groups were well balanced on measured baseline characteristics, residual confounding may still exist. However, PS matching only ensures balance between the groups in measured confounders. Multivariate analyses showed that the predictors of first CV event, CV mortality and all-cause mortality were similar in the intervention and the reference group. There were slight differences in the variable 'born in Sweden' in the intervention and the reference group in which six times more individuals were included.

We are not able to report exactly what kind of advice and support each individual received, nor what lifestyle changes it led to, or the effect on CV risk factors. We can only describe the programme as a whole. The programme, which was built to support a healthier lifestyle, was extensive and most of the focus was on supporting a physically active lifestyle. All healthcare personnel at the healthcare centres received theoretical and practical education in lifestyle medicine and CV prevention on a regular basis.

CONCLUSIONS

This study shows that participation in a primary healthcare-based CVD prevention programme focusing on promotion of physical activity and lifestyle changes, and management of risk factor disturbances, was associated with reduced risk of CV events, CV deaths and all-cause deaths after two decades. Although several randomised controlled lifestyle interventions have shown effects on incidence and mortality of CVD as well as total mortality, it remains a concern whether these lifestyle interventions are equally effective when implemented in everyday clinical practice. We find it encouraging that it was possible to implement a large-scale CV prevention programme in everyday clinical practice in primary healthcare. Furthermore, the findings reinforce the importance of identifying individuals at risk, promotion of physical activity and a healthy lifestyle and other risk factor interventions in primary healthcare to prevent CVD, the number one killer all over the world. The cost-effectiveness of the programme needs to be studied.

What are the findings?

► It was possible to implement and integrate a large-scale cardiovascular prevention programme focusing on lifestyle changes in primary healthcare.
► The programme led to lower rate of death from cardiovascular disease as well as lower total mortality in participants.
► Health benefits were seen in both women and men.

How might it impact on clinical practice in the future?

► Primary healthcare plays an important role in cardiovascular prevention.
► Support for lifestyle change, for example Physical Activity on Prescription, is effective in reducing cardiovascular risk.

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